BAE Systems Hybrid Propulsion Systems

AB 118 Investment Plan
Hydrogen Workshop

California Energy Commission
Sept. 29, 2009

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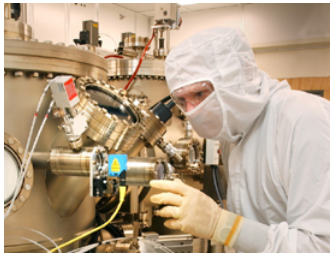
BAE Systems

BAE Systems is a premier global defense, aerospace & commercial products company delivering a full range of products and services for air, land and naval forces as well as advanced electronics, information technology solutions and customer support services to the world:

- A global capability
- Presence in over 100 countries & 37 states
- 105,000+ highly skilled employees
- No. 3 Global defense company
- Top Ten U.S. Prime Contractor
- Annual sales exceeds $33B
- Order book exceeds $76B



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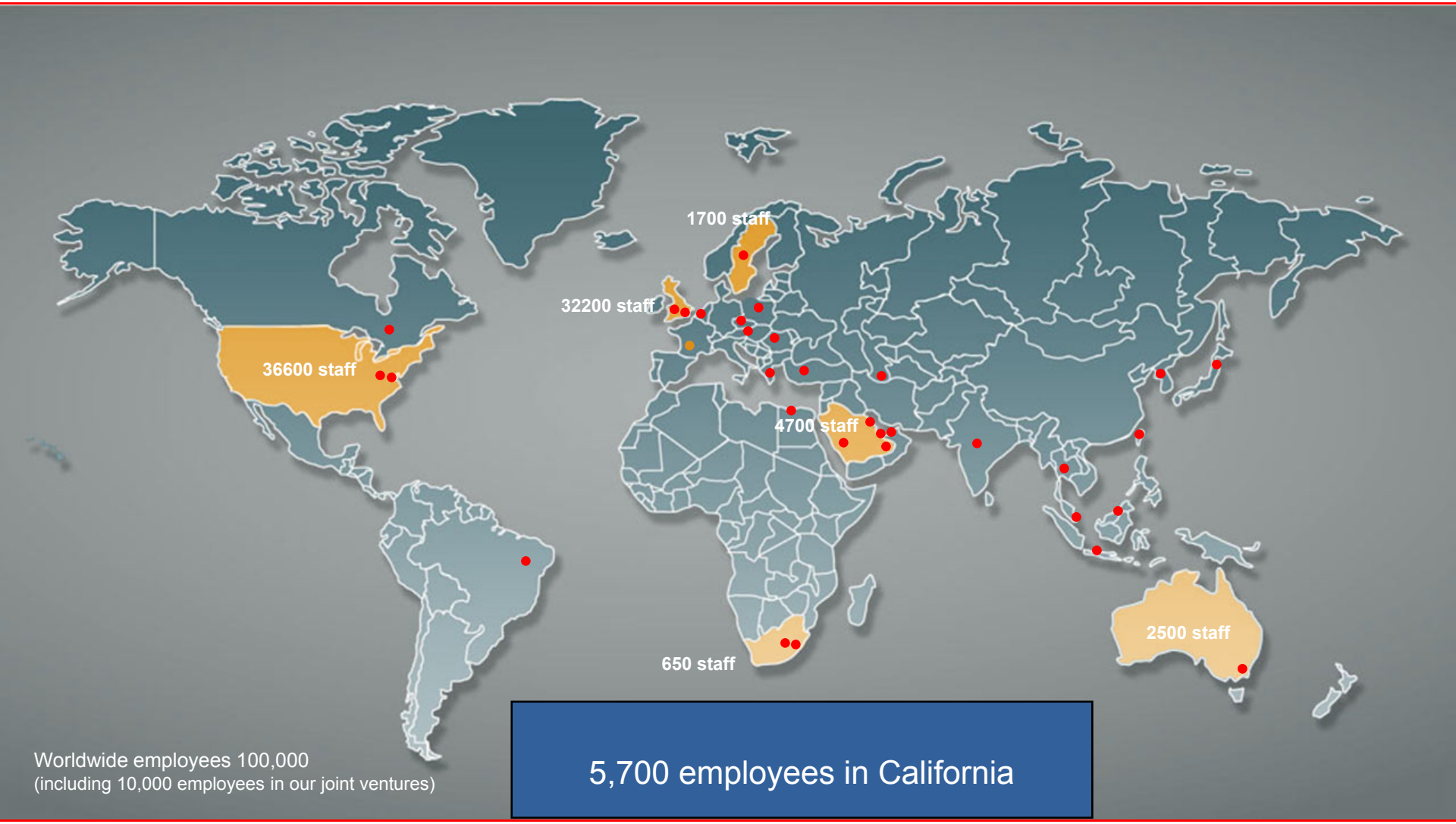
Global footprint: people



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Hybrid Bus Status

- Fleet
  - 2,300 propulsion systems delivered
  - World's largest hybrid bus fleet: New York City
  - Other major fleets: Toronto, San Francisco, Houston, Ottawa, London Seattle beginning in 2010
- Fleet Usage
  - 100 million miles cumulative
  - ½ million hours per month
  - 1 million passengers trips daily
- Public Benefits
  - 8 million gallons saved cumulative
  - 80,000 tons of CO2 prevented cumulative
  - 400 tons of NOx prevented cumulative
- Path Forward
  - Introduced new modular series hybrid system at APTA 2008

Proven in 2,300 units and 100 million miles

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World's largest hybrid fleet in New York City

- Largest (hybrid) bus order ever
  - 1,222 units delivered (241 Li-ion)
  - 453 on order
  - 80,000,000 cumulative miles
  - 52,000 miles per day
- Savings over first 10 million miles
  - 1,000,000 gallons of diesel fuel
  - 13,000 tons of CO2

"We are extremely pleased with the performance of the Orion Hybrids… It is impressive that these buses generate lower levels of exhaust emissions while, at the same time, consuming less fuel."

MTA Chairman Peter S. Kalikow, Nov 2005 Press Release

CALSTART

Winner Blue Sky Merit Award

California's largest hybrid fleet

- 3rd largest hybrid bus fleet in the US
- 86 units delivered
- Cleanest, quietest bus in the fleet after trolley
- Orion VII series hybrid deemed best hill climber
- Testing & evaluation encompassed competitor products

"This clean air bus will bring us one step closer to reaching the SFMTA goal of being emissions-free in San Francisco by 2020."

(GM, Nat Ford, SF MUNI)

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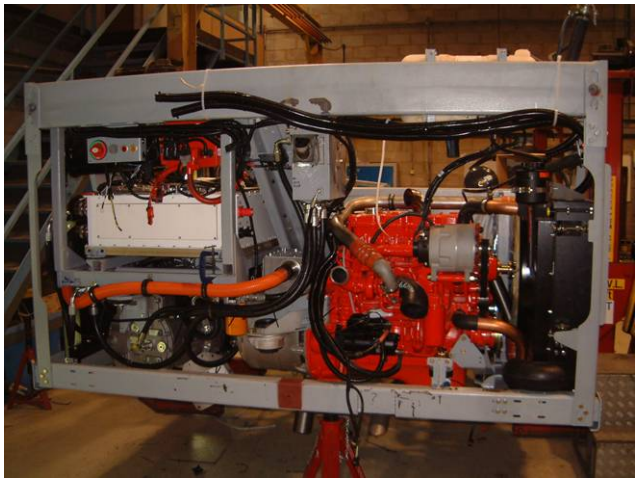
London's hybrid bus trial fleet

- London has announced plans to convert its entire bus fleet to hybrid electric
- BAE Systems is working with Alexander Dennis Ltd (ADL) on single and double deck buses for London and provinces
- First double deck demo bus chassis installed during 2007
- 17 units in hybrid fleet trials during 2009
- BAE Systems opened product application center in Rochester



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Hybrid Electric Drive Experience

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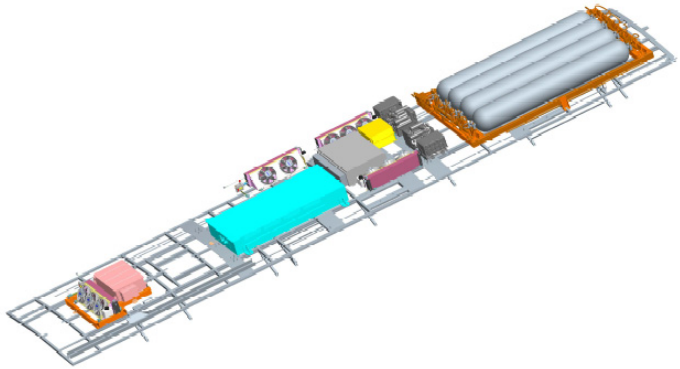
Bus 2010 Compound Fuel Cell Hybrid

- Scheduled for revenue service testing at S.F. Muni in 2010
- Hydrogen fuel and auxiliary systems roof racks completed
- Next Generation HybriDrive® system and electric accessories now being integrated
- Combines Fuel Cell & Hybrid Technologies
- Demonstrates electric accessory technologies required for fuel cell & other all electric options



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How does all this hybrid activity support Alternative Fuels & Hydrogen initiatives?

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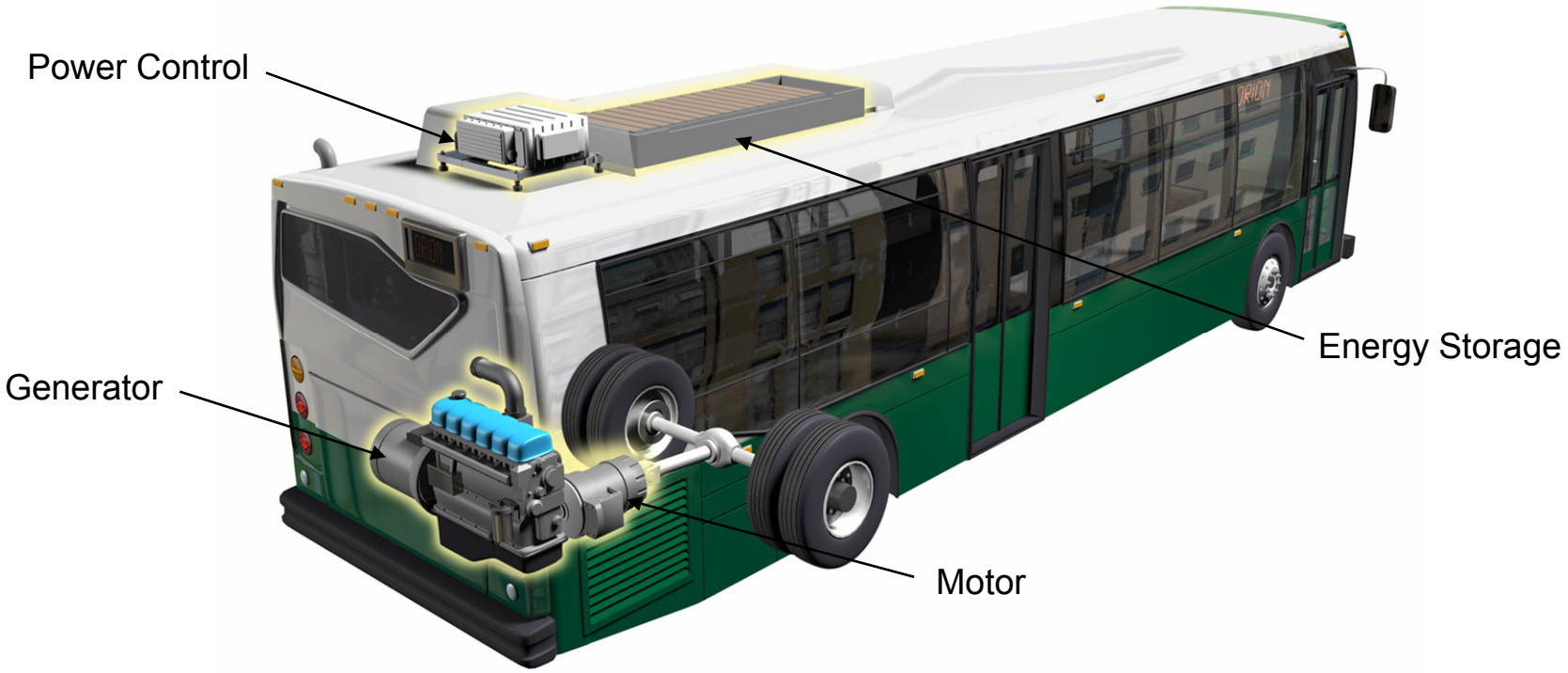
Series hybrid propulsion



Better fuel economy	Lower emissions	Reduced maintenance	Better reliability	Path to future

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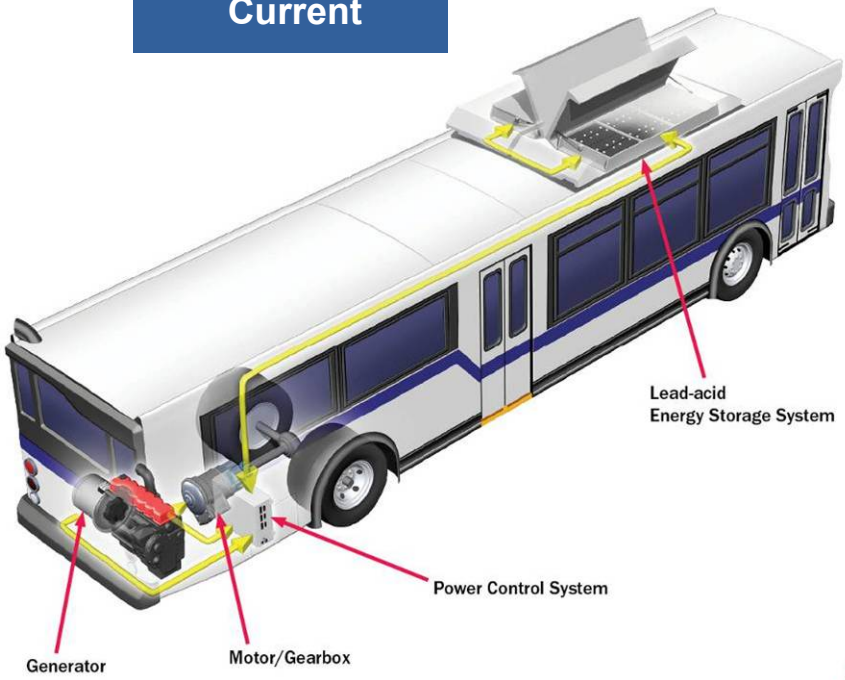
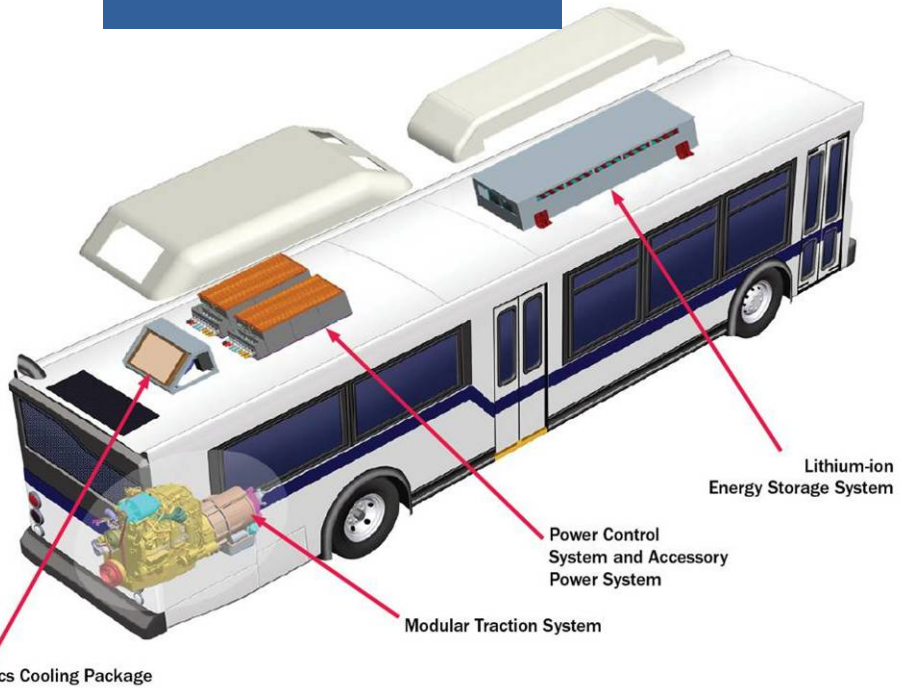
Product improvements

Current



Next Generation



Ongoing investment to add improvements and new features

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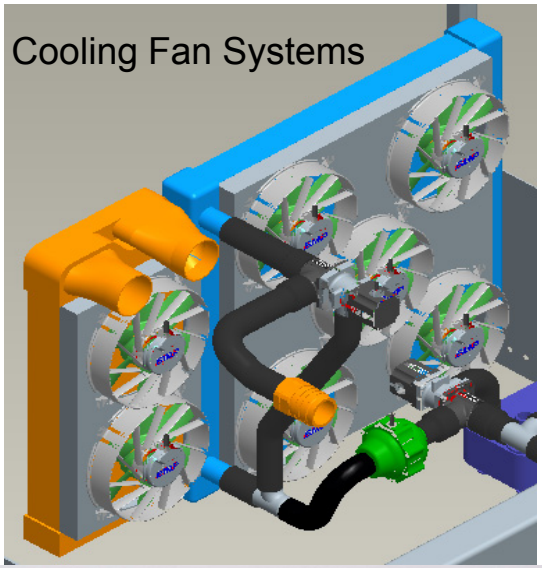
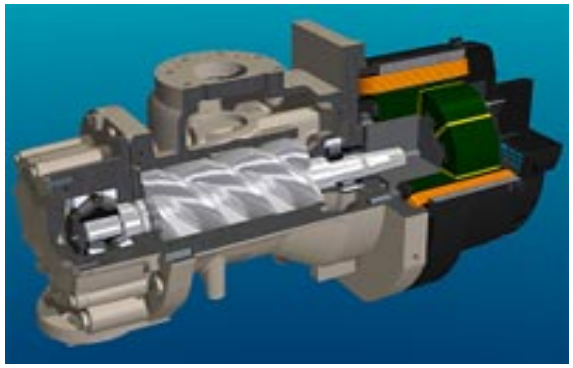
Next Generation System Electric Accessory Support

Air Conditioning

Auxiliary Heater





Air Compressor

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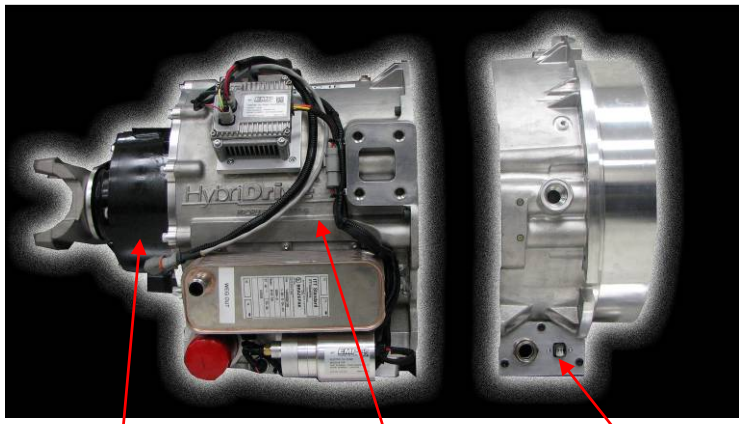
Modular Traction System

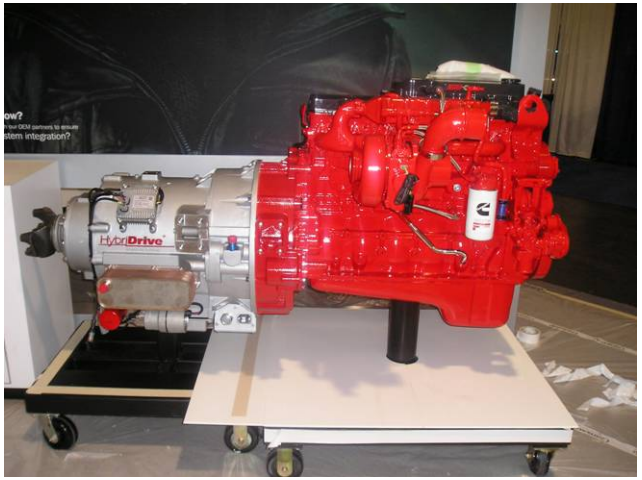


Alternating Current Traction Motor

Planetary gearbox

Alternating Current Traction Generator

- Integrated Starter Generator can be completely separated from Traction Motor
- Traction Motor/Gearbox includes complete support for cooling system
- ISG can be completely replaced with another power source, if available



MODULAR is a key part of the description

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Future Fuel Cell Vehicle Development Plans

- Working with:
  CALSTART, ZTUG Partners, Leading Fuel cell supplier, Leading Bus OEM and Hydrogen fuel facility supplier
- Working toward deployment of 50 or more fuel cell buses in multiple states including CA
- At least 25 buses targeted for Southern California
- Based on proven technology from each team member
- Goal is to deploy vehicles beginning in 2012
- Larger fleet size intended to bring vehicle costs down

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Panel Questions

- Challenges and Opportunities?
  - Main challenges are the known ones:
    Fuel cell cost, robustness & service life
    H2 fuel sources & facilities
  - Opportunities: More exploration of retrofit options (see below)
- Overlooked Applications?
  - Develop “Retrofit Ready” buses for fuel cell deployment
    - Demonstration program that develops 2 vehicle types:
      CNG-Hybrid bus and Fuel Cell bus that are 100% identical except for power plant
    - Provides mechanism for transit operators to acquire fleets of **truly** fuel-cell ready vehicles
    - Near term potential for CNG Hybrid volume purchases will help bring down cost of all accessory components required for fuel-cell implementation
    - Fuel cell retrofit can take place at 6 year major service interval or other convenient time period
    - Production orders can be switched to fuel cell in the factory as soon as volume production fuel cells are available

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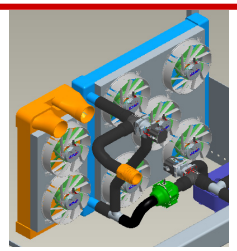
HybriDrive® Next Generation Transit Bus Layout



Propulsion Cooling Package
(Engine/Transmission)

Electronics Cooling Package

New Li-Ion Energy storage System

Auxiliary Power Supply For Electric Accessories

Propulsion Control System

In-Line Hybrid Modular Traction System

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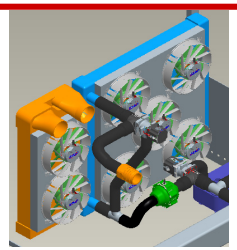
HybriDrive® Next Generation Transit Bus Layout



Propulsion Cooling Package
(Engine/Transmission)

Electronics Cooling Package

New Li-Ion Energy storage System

Auxiliary Power Supply For Electric Accessories

Propulsion Control System

Hybrid w/ Electric Accessories is a candidate for future retrofit

Summary

- Hybrid vehicle experience applies to future vehicle technologies
- Series Hybrid supports future goals
  - In-line T drive or Transverse installation
  - Electric Accessories
  - Fuel Cell ready
- Proven – 1000s of vehicles in revenue service
- Quieter operation, Smoother ride
- Go anywhere performance – city & highway speeds
- Retrofit options are a possibility
- BAE Systems is a reliable and proven partner

World Leader in Heavy Hybrid Technology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